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High Resolution Profiler Study of Deep Mixing in the Romanche Fracture Zone

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Technical Report

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Approved for Distribution:

Philip L. Richardson, Chair
Department of Physical Oceanography

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Abstract

Between November 20 and December 10, 1994, studies of the deep mixing processes in the Romanche Fracture Zone (RFZ) of the Mid-Atlantic Ridge were conducted from the French research vessel *N/O le Noroit*. Oceanographers from France and the U.S. worked together to acquire the unique data obtained on this expedition.

The cruise departed from and returned to Dakar, Senegal. Prior to the work in the RFZ, a sediment trap was recovered and returned to port. Two HRP engineering test dives were completed on the way to the fracture zone. The next week and a half was spent profiling with the HRP and CTD along the channel of the RFZ to identify regions of especially intense mixing. After that, two trans-equatorial sections were done with the HRP to examine the structure and intensity of the equatorial jets.

The presence of bottom intensified flow to the east along the RFZ and enhanced mixing of Antarctic Bottom Water were both observed. Based on the measurements obtained during this experiment, transport through the RFZ is estimated to be 1 Sv.

The work at sea, instrumentation, data return and some preliminary results are presented in this report.

Overview

The Romanche Fracture Zone Experiment took place in November/December, 1994. The primary objective of the experiment was to quantify the mixing of Antarctic Bottom Water (AABW) and North Atlantic Deep Water (NADW) within the Romanche Fracture Zone (RFZ), which would allow the transport of AABW through the fracture zone to be understood in a dynamical context. The secondary goals of this experiment were: (1) to investigate wave/mean flow interactions between high frequency internal waves and deep, equatorially trapped jets, and (2) to define the bottom enhancement of turbulent mixing away from the sill regions. Despite some instrument malfunctions, which will be discussed in the instrument section, we were successful in achieving the goals of the experiment.

The instruments used to acquire the high quality, finely sampled data for this study were the High Resolution Profiler (HRP) and a Seabird Seacat CTD. The HRP provides estimates of oceanic velocity, conductivity, temperature, pressure and microstructure (turbulence) variances. Since the outer scales of turbulence were large enough to be resolved by a CTD in this environment, the Seacat was used to increase our spatial-temporal sampling. A total of 55 HRP and 18 CTD stations were occupied during this cruise. HRP dives 3–30 were in the fracture zone which is where corresponding CTD measurements exist. Dives 31–42 were equatorial transects to study the deep jets and have no corresponding CTD data. Figure 1 shows the cruise track and the HRP stations.

The emphasis of this report will be on the HRP work completed during the cruise. A cruise log, a description of the HRP, a data summary and some preliminary results are presented in the sections following.

This was a joint US/French expedition: the *N/O le Noroit*, her crew, and the scientists from the Laboratoire de Physique des Oceans (LPO) of the Institute Francais pour Recherches de Mer (IFREMER) conducting the CTD work are French, and the HRP group from Woods Hole Oceanographic Institution (WHOI) are American. The language differences posed some problems, but several of the scientists and one officer were bi-lingual, which made communication possible. The officers and crew were capable ship handlers, and responsive to our needs, so we had no difficulties with deployments and recoveries of either instrument.

The science party was comprised of participants from three institutions, as listed below:

Scientist	**Affiliation**	**Instrument**
Kurt Polzin	U. Washington	HRP – Chief Scientist
Kevin Speer	LPO/IFREMER	CTD – Co-Chief Scientist
Ray Schmitt	WHOI	HRP
John Toole	WHOI	HRP
Ellyn Montgomery	WHOI	HRP
Dave Wellwood	WHOI	HRP
Tom Bolmer	WHOI	HRP
Jean-Peirre Giradot	LPO/IFREMER	CTD
Thierry Penduff	LPO/IFREMER	CTD

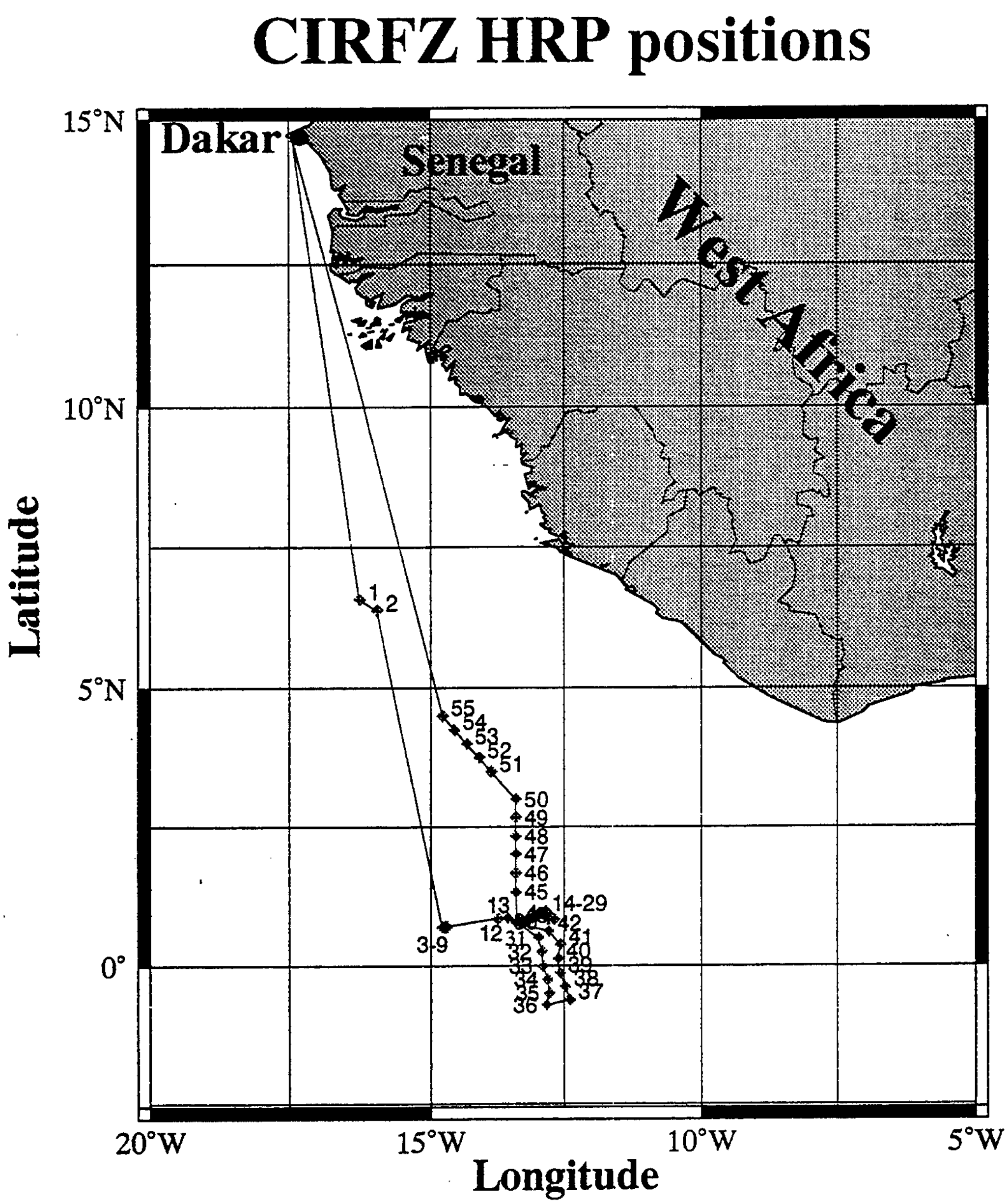

Figure 1: Cruise track showing High Resolution Profiler dive locations

Cruise Log

The *Noroit* departed Dakar, Senegal, at 1600 on Friday, November 18 with a full science complement. We transited to 14°40′N, 18°25′W to recover a sediment trap deployed the previous year by an investigator from the College of Charleston. The ship returned to Dakar on Nov. 20 to disembark personnel from the College of Charleston.

We enjoyed fair weather throughout this cruise: The southeast trades were steady at 10–15 knots, the days were mostly sunny with highs in the 90's and calm seas. We encountered occasional showers, but no major storms. In general, working conditions were very pleasant, and we never had to stop work to wait out bad weather.

After the *Noroit's* second departure from Dakar, we headed for a site at which to do two engineering test dives with the HRP. We stopped at a location outside of Africa's territorial waters on the way to the Romanche Fracture Zone and did one dive to 500 meters followed by a second to 1000 meters. This was to allow all the component systems and sensors to be tested without spending the time needed (about 5 hours for 4000 meters) to do a full depth dive. Later sensor failures were experienced due to extreme depths, so testing to the maximum planned depth should really be done.

When the engineering dives were completed, we continued to the first full depth work site at 0°45′N, 14°45′W. This site was an isolated sill to the west of the Main Sill in the RFZ. We commenced working there November 23 at 2300 and completed 13 stations (seven HRP and six CTD profiles) around this sill. As we profiled over this sill, we encountered water depths of 4000–4700 meters deep, and profiled to within 40 meters of the bottom on five of the seven HRP dives.

We encountered the first problems with the HRP during these first deep stations. It appeared that the A/D converter had failed, causing electrical problems, but in reality it turned out to be leaks in the shear probe canisters, which only occurred at depths greater than 4000 meters. The cause was identified as wicking of sea water along the output wires past the epoxy plug/sensor tip. Using probes from an earlier experiment that employed another epoxy and different coating on the wires solved the problem. We also found that the software controlling the interface to the acoustic altimeter was not doing exactly what was expected. Another version of the code was made and refined during the early dives, to allow robust functioning near the seafloor.

As we corrected the problems, we moved to the area of the Main Sill and the eastern part of the RFZ. Figure 2 shows the bathymetry of this area. Features such as the eastern sills and certain stations referred to in this report are marked on it. Note that the sill to the west, at which we started work is off the map to the left, since including that area would make it impossible to see the details of the eastern part of the RFZ.

Stations 12 and 13 were made on November 26 at the Main Sill in the channel of the Romanche. The next 20 HRP dives were made along the channel to the east, as we explored the likely routes taken by the AABW. Our deepest stations were greater than 5000 meters and were made in the far eastern part of the RFZ as it opens into the Sierra Leone Basin. These are the deepest microstructure measurements taken to date. With the altimeter allowing close bottom approaches, we were able

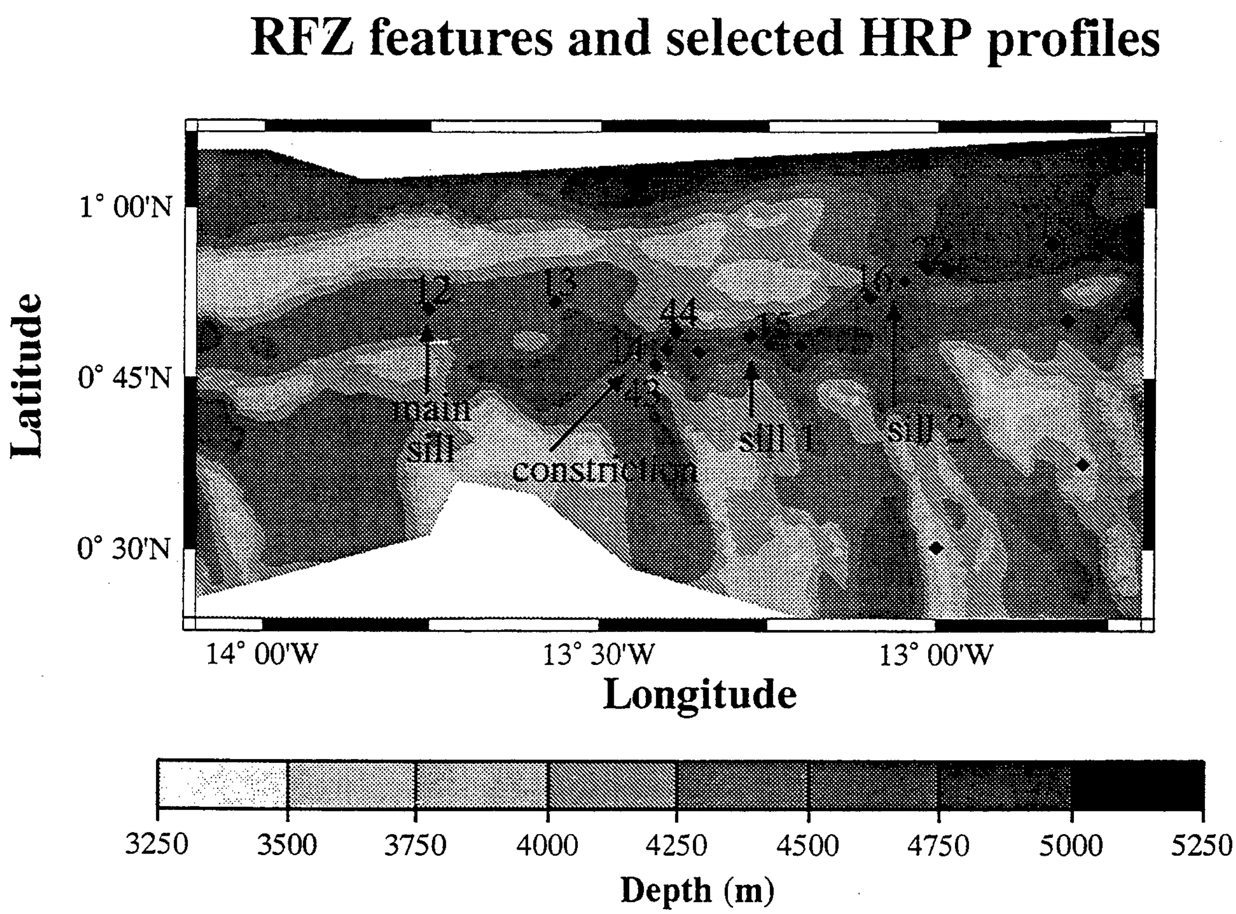

Figure 2: Bathymetry detail of the eastern part of the Romanche Fracture Zone. Selected topographic features and the locations of selected HRP profiles are labeled.

to observe the bottom intensification of turbulent mixing. On station 23 the HRP dove to 20 meters off the bottom for the first time on a 4775.3 meter profile. Most of the dives between 12 and 30 ended between 30 and 50 meters from the bottom, some terminating due to pressure, others due to range criteria being met.

On November 30, we commenced two equatorial transects to examine the structure and intensity of the deep jets. Dives 31–36 comprise the more westerly southbound section and dives 37–42 make up the northbound one slightly to the east. These stations varied between 3600 meters and 4500 meters deep, depending on the topography. We were able to get nearer than 30 meters from the bottom on four of these, the rest ended a little farther off the seafloor.

On December 3, we returned to the area of the RFZ we call "the constriction" to do two more profiles (43 and 44) there, attempting to obtain a cross-channel transport estimate. Both of these profiles ended 20 meters from the bottom. Used with dive 14, which ended 30 meters from the bottom, we hoped to get a fairly good estimate. Unfortunately the HRP's platinum thermometer failed on dive 43, and we were unable to fix it, so the rest of the profiles did not acquire good temperatures. We expect to be able to use the microstructure thermistor data to reconstruct reasonable temperature data for dives 43–55.

We left the RFZ at midnight December 3. On the transit north, we took the opportunity to obtain a full depth meridional section from 1°to 3°N (dives 44–50) and five profiles to 2000 meters between 3.5°and 4.5°N. We returned to Dakar at 2000, Thursday, December 8. A summary of information pertaining to all the HRP dives taken on this cruise is presented in Table 1, the CTD dives are summarized in Table 2, and the dives that terminated based on range from the bottom are shown in Table 3.

Table 1: **HRP Profiles Taken During the *Noroit* Cruise**

Dive #	Date mo/day 1994	Time GMT	Deployment Latitude		Longitude		Pmax R = range Terminated	Comments
			(− = South & West)					
1	11/22	0815	6	34.287	−16	17.781	500.3	−1st test dive
2	11/22	1609	5	22.380	−15	58.387	1000.1	−2nd test dive
3	11/23	2310	0	42.028	−14	48.047	4509.0	−section over
4	11/24	0433	0	41.935	−14	46.346	4476.0	western sill of
5	11/24	0932	0	41.953	−14	45.075	4532.2	the Romanche FZ
6	11/24	1622	0	41.851	−14	43.884	4170.0	"
7	11/24	2205	0	42.110	−14	43.110	4721.8	"
8	11/25	0331	0	42.153	−14	42.031	4301.2	"
9	11/25	0818	0	41.508	−14	44.326	4301.2	"
12	11/26	0616	0	51.055	−13	45.153	4395.6	−at main sill RFZ
13	11/26	1300	0	51.744	−13	34.080	4401.0	−downstream of main sill
14	11/26	1815	0	47.496	−13	24.019	4701.2	−at constriction
15	11/26	2314	0	47.970	−13	14.857	4701.1	−at sill 1
16	11/27	0533	0	52.101	−13	5.988	4696.1	−at sill 2
17	11/27	1213	0	54.666	−13	0.954	4792.3	−in outflow region
18	11/27	1816	0	56.733	−12	49.988	4917.9	"
19	11/27	2359	0	50.590	−12	41.554	5308.0	"
20	11/28	0610	0	50.003	−12	48.682	4676.0	"
21	11/28	1424	0	53.479	−13	3.053	4576.5	"
22	11/28	2008	0	54.560	−13	0.812	4846.4	−downstream of sill 2
23	11/29	0314	0	54.697	−13	1.104	4775.3	"
24	11/29	1000	0	54.671	−13	1.095	4795.3	"
25	11/29	1457	0	54.415	−12	59.187	4989.1	"
26	11/29	2039	0	56.502	−12	59.164	4905.3	"
27	11/30	0158	0	47.820	−13	12.170	5120.1	−downstream of sill 1
28	11/30	0741	0	48.037	−13	16.565	4736.2	"
29	11/30	1349	0	47.245	−13	21.105	4682.1	−near constriction
30	11/30	1825	0	47.559	−13	24.055	4749.8	"
31	11/30	0139	0	29.994	−12	59.995	3640.0	−equatorial section 1
32	12/01	0627	0	14.973	−12	56.043	4305.1	"
33	12/01	1130	0	0.017	−12	55.142	3810.2	"
34	12/01	1617	−0	14.950	−12	49.266	4096.9	"
35	12/01	2106	−0	29.886	−12	47.415	4060.1	"
36	12/02	0206	−0	43.031	−12	50.353	4340.2	"
37	12/02	0920	−0	37.312	−12	23.770	4100.1	−eq. section 2
38	12/02	1348	−0	22.552	−12	29.132	3950.2	"
39	12/02	1811	−0	7.566	−12	35.202	4520.1	"
40	12/02	2309	0	7.560	−12	37.519	4401.4	"
41	12/03	0400	0	22.526	−12	34.673	4778.5	"
42	12/03	0927	0	37.501	−12	47.335	3897.7	−end eq. sections
43	12/03	1551	0	46.096	−13	24.980	4392.7	−at constriction
44	12/03	2038	0	49.094	−13	23.180	4498.2	"
45	12/04	0249	1	19.965	−13	25.025	4820.0	−Northward section
46	12/04	0829	1	40.023	−13	24.991	5202.6	"
47	12/04	1421	1	59.994	−13	24.978	4970.2	"
48	12/04	1949	2	19.876	−13	24.929	5078.0	"
49	12/05	0128	2	40.065	−13	24.924	4713.9	"
50	12.05	0654	3	0.003	−13	24.892	4745.1	"
51	12/05	1425	3	29.945	−13	52.692	2020.0	−along African
52	12/05	1808	3	44.906	−14	6.085	2020.1	coast outside the
53	12/05	2159	3	59.958	−14	20.334	2020.0	territorial limit
54	12/06	0240	4	15.000	−14	34.110	2020.4	"
55	12/06	0636	4	29.929	−14	47.784	2020.1	"

Table 2: **CTD Stations Completed on the *Noroit* Cruise**

CTD #	Date mo/day 1994	Time GMT	Deployment Latitude (– = South & West)		Longitude		Comments
1	11/22	0748	5	22.920	–15	59.460	at western sill with HRP 3
2	11/24	0621	0	41.979	–14	46.525	with HRP 4
3	11/24	1240	0	42.000	–14	45.000	with HRP 5 -
4	11/24	2000	0	42.180	–14	45.300	repeat of previous dive
5	11/25	0537	0	42.214	–14	42.178	with HRP 8
6	11/25	0658	0	41.700	–14	44.460	with HRP 9
7	11/25	1135	0	42.707	–14	44.381	
8	11/25	1730	0	42.000	–14	45.180	tow–yo
9	11/26	1106	0	51.068	–13	34.174	with HRP 12 at main sill
10	11/27	0400	0	52.230	–13	6.240	with HRP 16
11	11/27	0935	0	54.755	–13	1.250	with HRP 17
12	11/28	0420	0	49.860	–12	49.000	with HRP 20
13	11/28	1712	0	52.870	–13	5.740	after HRP 21
14	11/28	2203	0	54.630	–13	1.080	tow–yo with HRP 22
15	11/28	2344	0	54.730	–13	1.243	with HRP 23
16	11/29	0638	0	54.640	–13	1.070	with HRP 24
17	11/29	1400	0	54.480	–12	59.220	with HRP 25
18	11/29	2259	0	56.450	–12	59.230	with HRP 26

Table 3: **HRP Dive Parameters for Profiles Terminated by Range**

Dive #	Date mo/day	Time GMT	Pressure to Turn-on Altimeter	Range At Dive End	Pressure At Dive End
4	11/24	0 433	3200.0	50.0	4476.0
5	11/24	0932	4000.0	40.0	4532.2
7	11/24	2205	4300.0	40.0	4721.8
8	11/25	0331	4300.0	40.0	4301.2
9	11/25	0818	4300.0	50.0	4301.2
12	11/26	0616	4335.0	40.0	4395.6
13	11/26	1300	4400.0	30.0	4401.0
14	11/26	1815	4700.0	30.0	4701.2
15	11/26	2314	4700.0	30.0	4701.1
16	11/27	0533	4695.0	50.0	4696.1
20	11/28	0610	4675.0	40.0	4676.0
21	11/28	1424	4575.0	30.0	4576.5
22	11/28	2008	4840.0	30.0	4846.4
23	11/29	0314	4770.0	20.0	4775.3
26	11/29	2039	4900.0	30.0	4905.3
28	11/30	0741	4735.0	30.0	4736.2
30	11/30	1825	4740.0	30.0	4749.8
34	12/01	1617	4050.0	30.0	4096.9
40	12/02	2309	4400.0	30.0	4401.4
41	12/03	0400	4740.0	20.0	4778.5
42	12/03	0927	3850.0	20.0	3897.7
43	12/03	1551	4350.0	20.0	4392.7
44	12/03	2038	4450.0	20.0	4498.2

HRP Instrument Description

The High Resolution Profiler (HRP) is an oceanographic instrument designed to collect fine- and microstructure data during vertical profiles. A schematic of the HRP's structure and component systems is shown in Figure 3. To minimize ship-induced noise in the measurements, the HRP dives without attachment to the ship. It is deployed, falls freely while collecting data, drops its weights at a user-specified pressure, stops data acquisition, puts the computers in a wait state to conserve power, and rises to the ocean surface where it can be recovered. Once recovered and on deck, the data are downloaded from instrument memory to a shipboard computer where analysis and archival occurs.

The HRP has two profiling modes: fine and micro, with the transition between them triggered by the CTD's pressure reaching user-defined threshold values. Fine sensors (including the CTD) are sampled at 10 Hz, and microstructure sensors are sampled at 200 Hz, with fine sampling continuing throughout the period of micro sampling.

Up to 16 sensors may be added to the HRP to complement the basic CTD measurements. The profiler is designed for versatility, so its configuration is determined by whichever suite of sensors is connected to the available channels. The configuration used for this experiment follows:

Fine Sensors	A/D Channel
pressure	–
temperature	–
conductivity	–
accelerometer top X	0
accelerometer top Y	1
accelerometer bottom X	2
accelerometer bottom Y	3
acoustic current meter X velocity	4
acoustic current meter Y velocity	5
X magnetometer	6
Y magnetometer	7
A/D ground	14

Micro Sensors	A/D Channel
differential conductivity	10
differential temperature	11
shear X	12
shear Y	13

At a nominal descent rate of 0.6 meters/second, a 4000 meter dive takes two hours for descent, and one hour for ascent. During the dive, two megabytes of fine data and 12 megabytes of micro data will be acquired and stored, given the above configuration. The transfer of data from the HRP is accomplished using a serial (RS232) connection operated at a nominal speed of 38.4 Kbaud. We

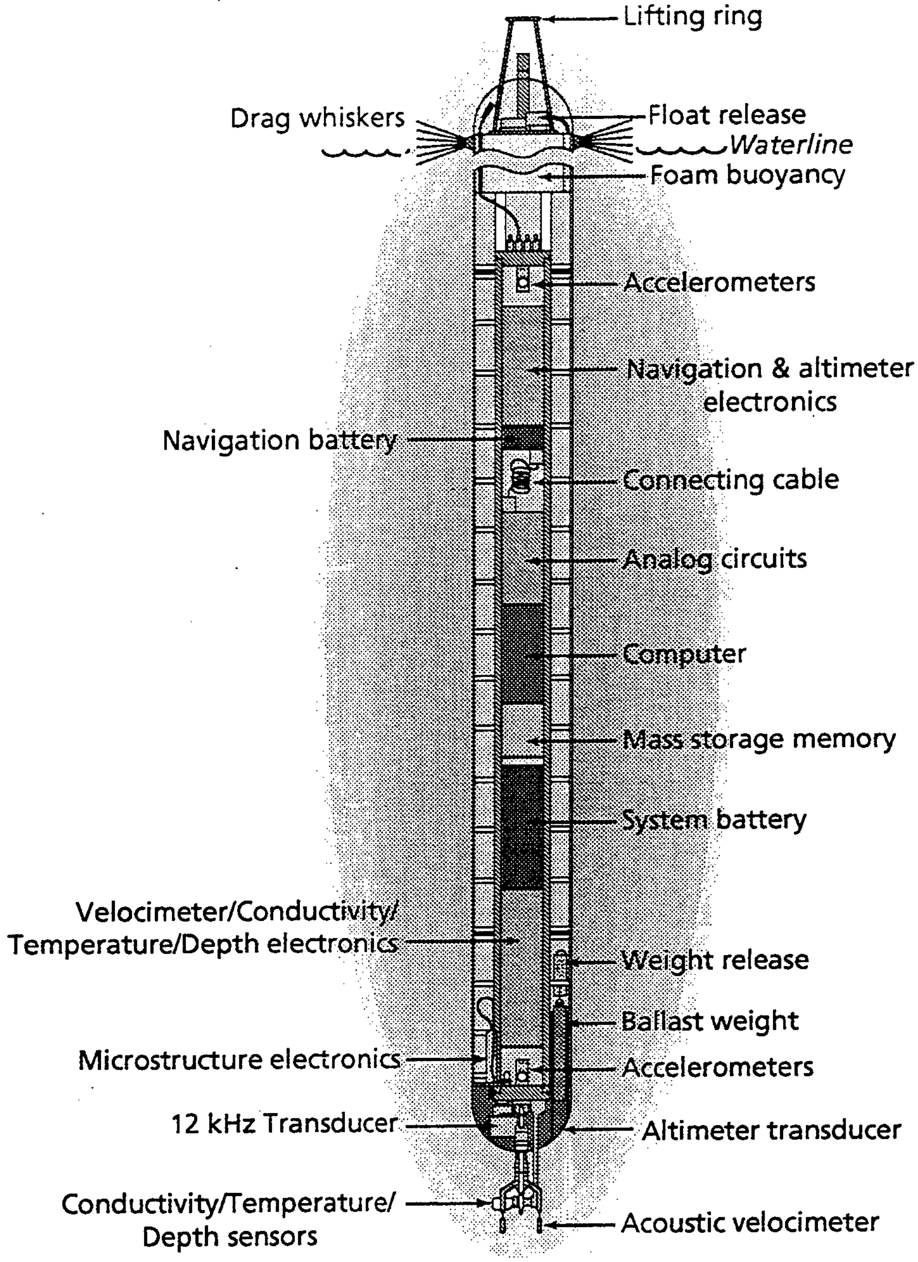

Figure 3: Schematic of the High Resolution Profiler (HRP)

obtain an actual speed of 34 Kbaud, which means it takes an hour and a quarter to transfer the data from the HRP to computers on the ship. Adding some time to maneuver during recovery, it took four and a half to five hours to complete a deep HRP profile.

Prior to this cruise, coding changes were incorporated and tested to allow the acoustic altimeter (added to the HRP for the Abrupt Topography experiment) to function more robustly. The experimental design called for close approaches to the bottom in areas of rough and rapidly changing bottom topography, so having the ability to terminate at a pre-set range in addition to terminating at a pre-set pressure was important. With some additional tweaking on the cruise, we were able to use the altimeter to provide accurate ranges with confidence.

We had two major hardware malfunctions on the cruise. First, working at greater depths than we had previously (4000 to 5000 meters) caused the shear probes to leak. Fortunately the leak was isolated in the shear probe canisters, and so the main computer was not affected. Once we started using the probes from a previous experiment that were fabricated using a different epoxy, no more leaks were experienced.

The second problem was with the CTD's platinum thermometer. It appears that use on repeated profiles to greater than 4500 meters caused the sensor to fail prematurely. The thermometer was new for this experiment, so we did not anticipate its failure and had no spare. Fortunately, it failed near the end of the cruise, after we had achieved the primary goals of the experiment. We hope to use the microstructure temperature gradient data to estimate the missing CTD temperatures for the stations where the thermometer did not work.

For additional information on the development of the HRP, see the papers by Schmitt *et al.*, (1988 and 1995) and for operational details of the HRP see the technical report by Montgomery (1991).

Data Processing

The HRP acquires and stores fine, micro and range data. The raw data are transferred to and processed on shipboard workstations using programs developed especially for use with the HRP.

The raw HRP data of all three kinds are stored as counts in binary format. The first step of the processing is to convert the raw numbers to scientific units and apply some nominal calibrations. This data is stored in a binary format designed by Millard and Galbraith (1982) to conserve disk space. Quality control (QC) plots are made for the fine and microstructure data channels immediately after the conversion to scientific units is completed. The quality control plots show if there is a problem with any of the sensors that should be fixed before the next deployment. An example of these plots using profile 30 is shown in Figures 4a–d.

As the QC plots are generated, a program is run that computes finescale velocity, potential temperature–salinity profiles and bins the data in a uniformly incremented pressure series (typically 0.5 db). The velocity computation employed is described by Schmitt *et al.* (1988) and uses the acceleration and magnetometer data to correct the raw acoustic current meter data for instrument motion. Laboratory-derived calibration data are used to convert raw pressure and tem-

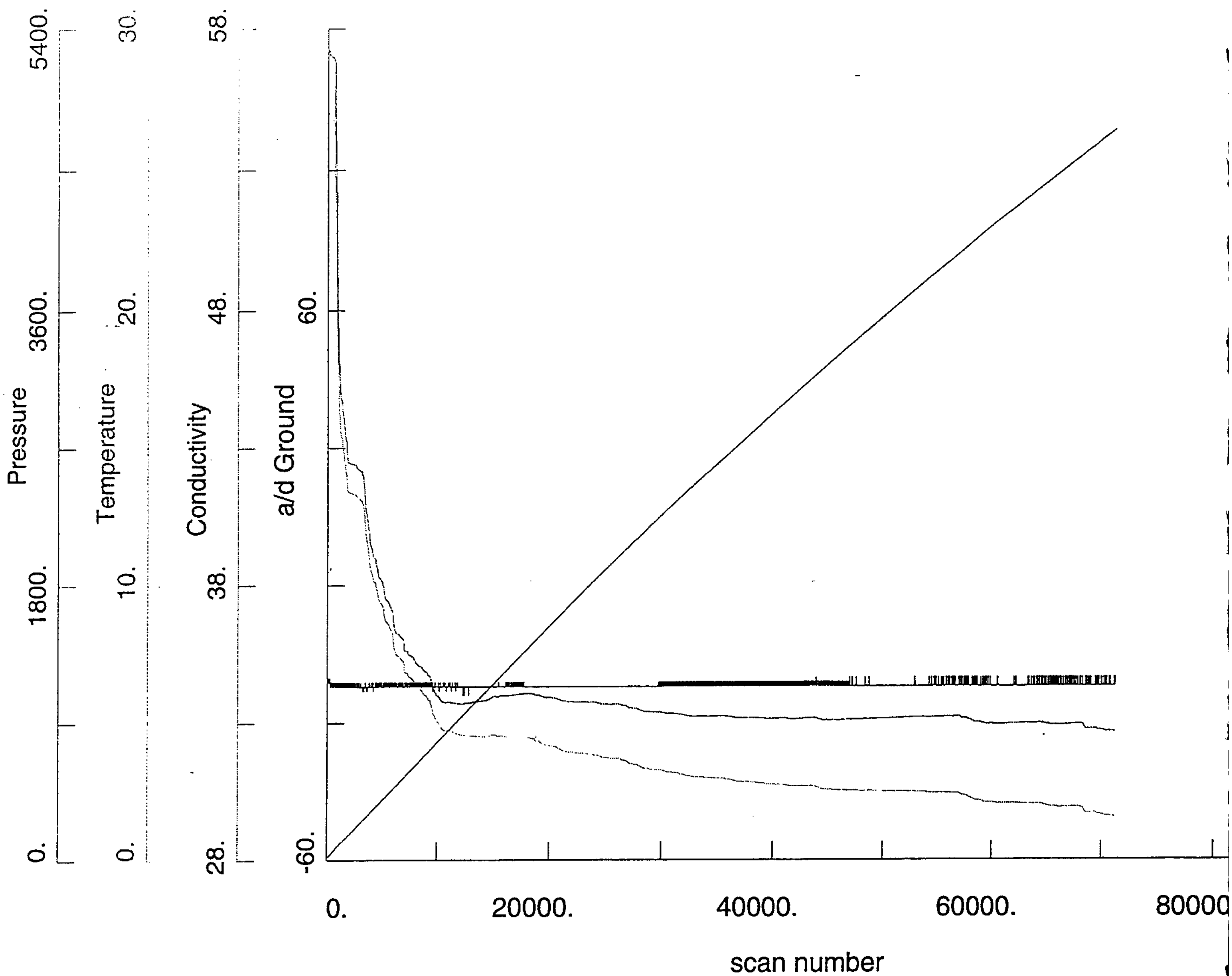

Figure 4a: Finestructure quality control plot of temperature, conductivity, pressure and A/D ground plotted against scan number.

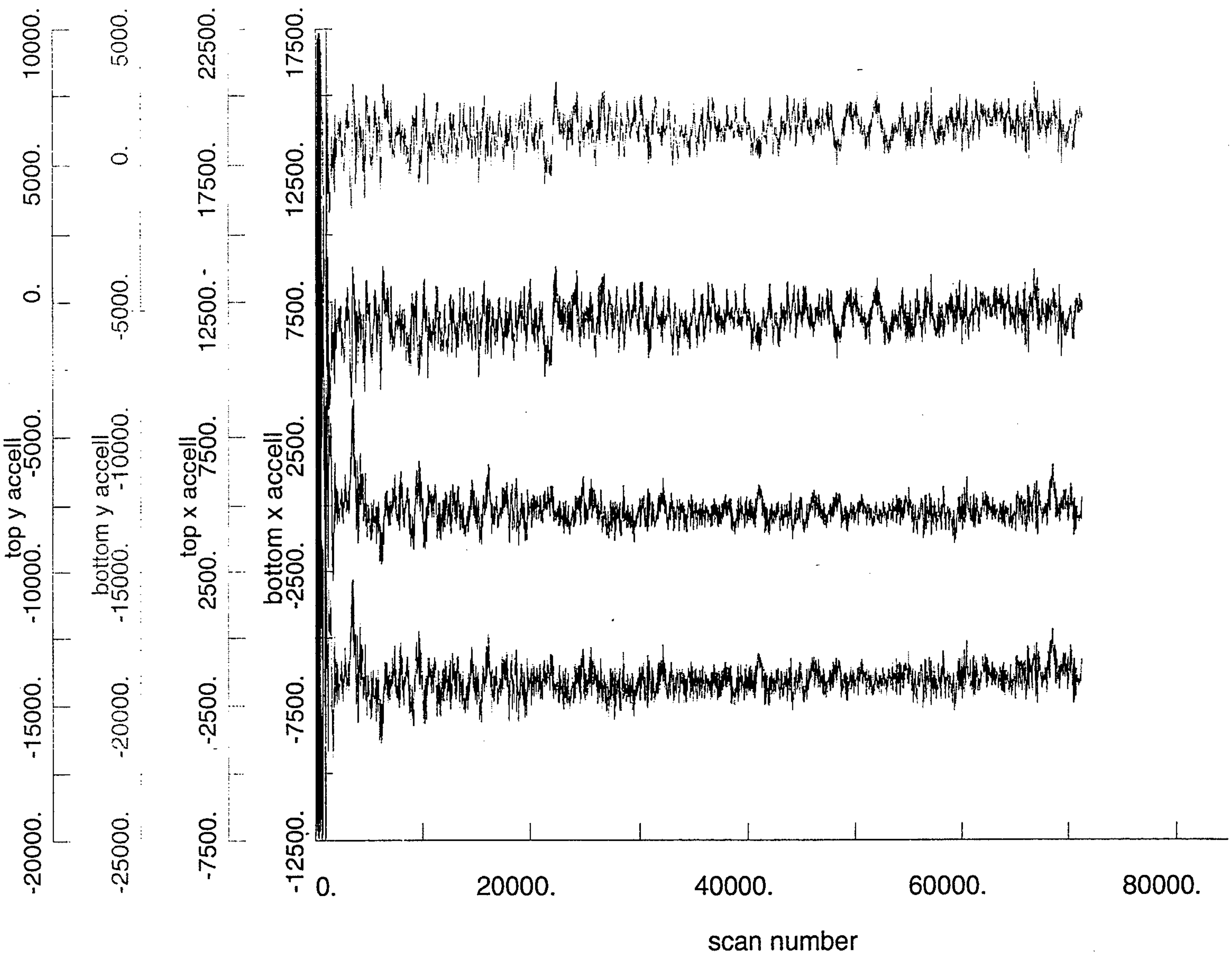

Figure 4b: Finestructure quality control plot of accelerometer channels (top $x - y$, and bottom $x - y$) plotted against scan number.

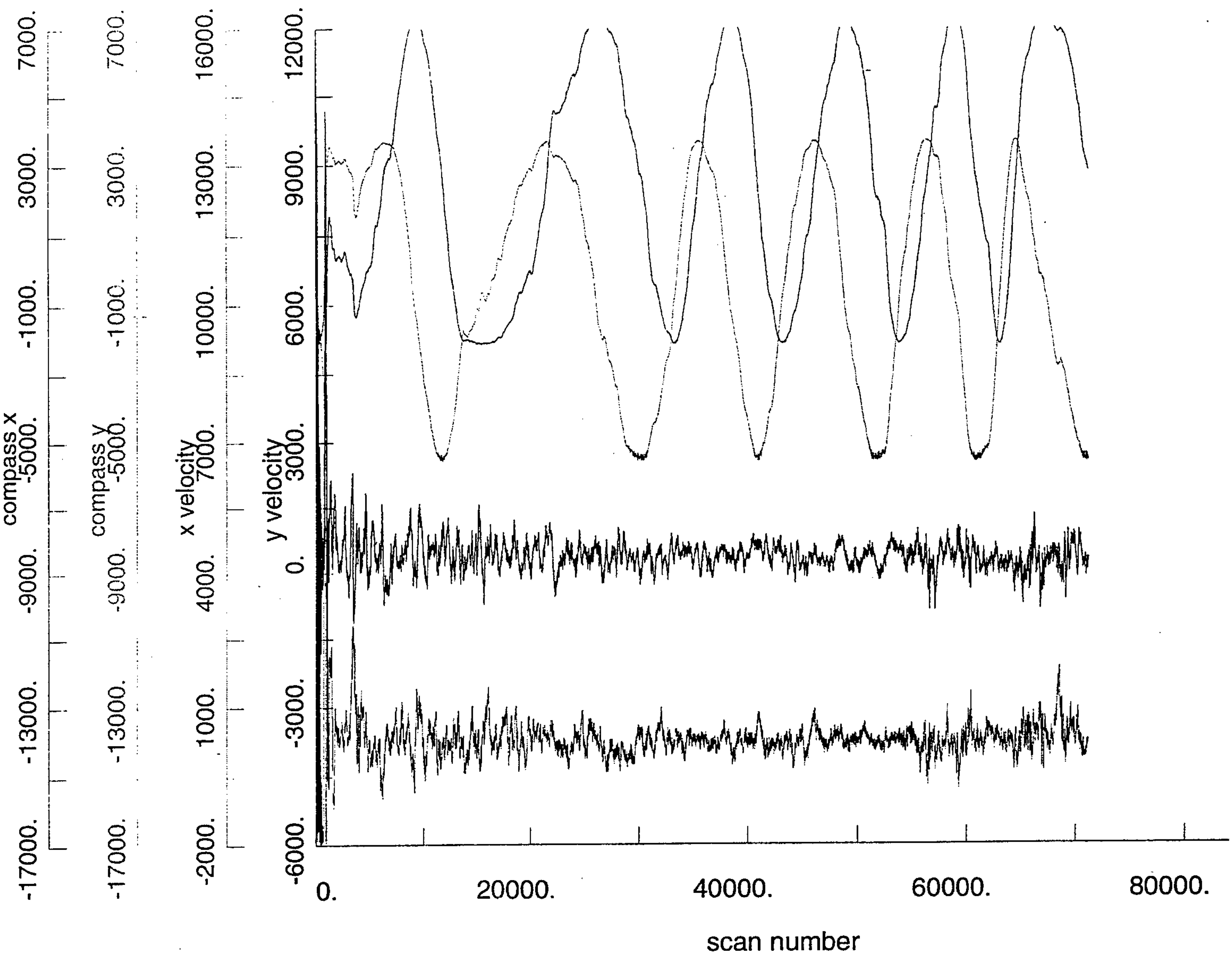

Figure 4c: Finestructure quality control plot of velocimeter and compass channels plotted against scan number.

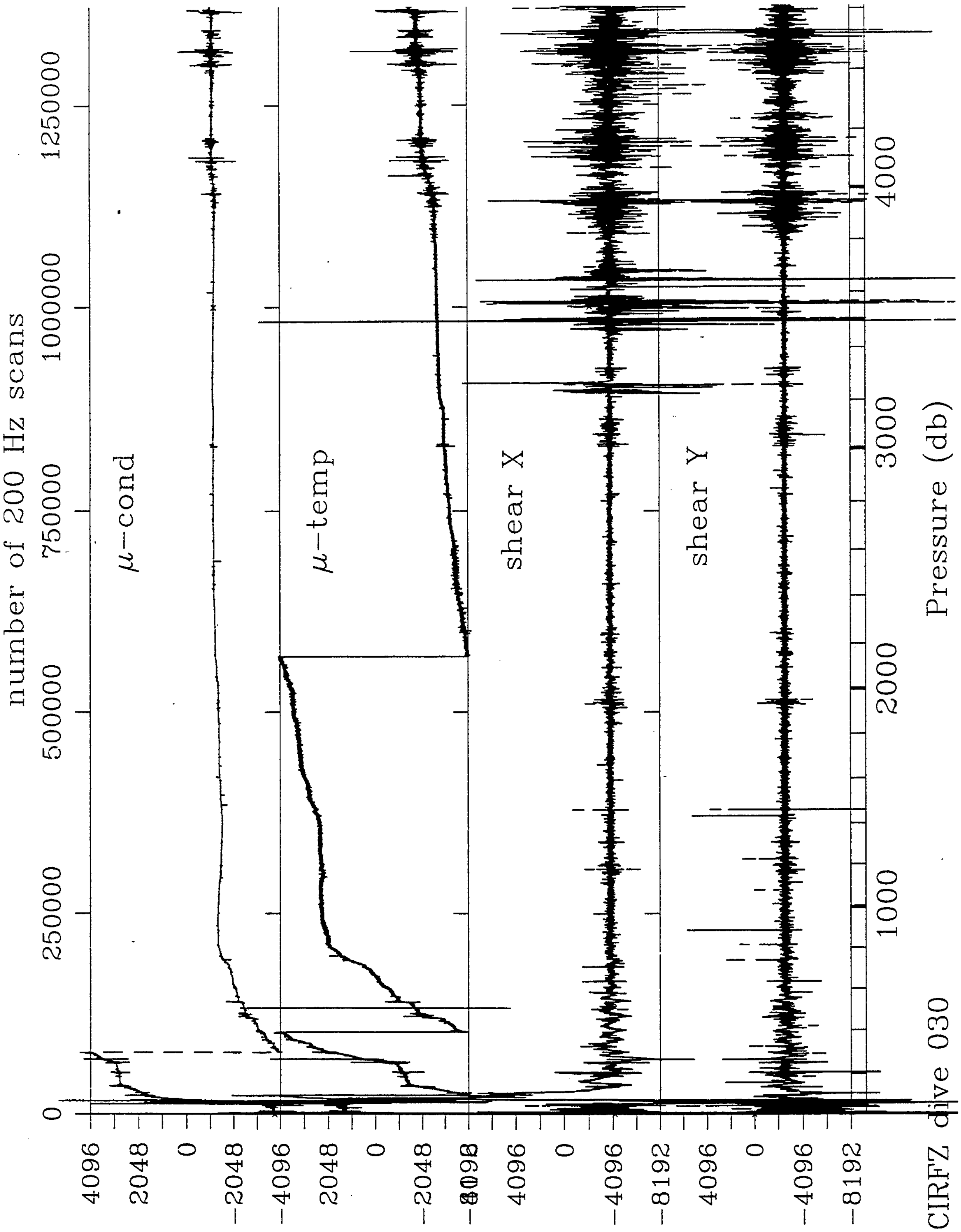

Figure 4d: Microstructure quality control plot of shear and differential temperature and conductivity plotted against pressure.

perature data to scientific units. A laboratory-derived relationship is also utilized for the initial estimate of the conductivity cell calibration. Adjustments of this scale are subsequently derived to obtain consistent deep water potential temperature–salinity relationships. The output is stored in another binary file from which a plot of temperature, salinity, east and north velocities versus pressure is created. An example of this type of plot, again, using profile 30, is shown in Figure 5.

Microstructure data processing is started concurrently with the fine, but takes much longer to complete due to more densely sampled data and more computations performed. The scheme used follows procedures developed by Neil Oakey (Bedford Institute of Oceanography). A report by Polzin and Montgomery (in preparation) will describe the microstructure data processing, so only a brief summary is included here.

The processing utilizes laboratory-derived calibration coefficients of the shear probes (micro-scale velocity sensors), while in-situ calibration data for the microscale temperature and conductivity sensors are obtained by reference to the finescale temperature and conductivity from the HRP. The microstructure data are binned in the time blocks aligned with the uniformly incrementing pressure series of the reduced finescale data. Gradient variances are estimated in the frequency domain after fast Fourier transforming by integrating spectra out to a local minimum in energy density. Spectral corrections are then applied for the finite responses of the sensors. After automated edit and consistency checking, scaling to scientific units yields estimates of the kinetic energy dissipation rate (ϵ, epsilon), and two measures of the dissipation rate of thermal variance (from the microscale temperature and conductivity sensors: Chi-T and Chi-C respectively). Profile plots (in "stick-diagram" form) of the dissipation rates are then produced, an example of which (again using profile 30) is shown in Figure 6.

The range data from the altimeter is converted to ascii and checked to determine the range from the bottom at weight release and the rate of data return. Often the pressure criteria terminated the dive before the altimeter was able to resolve any echos from the bottom. Some dives however did log good returns, which help continue evaluation of the altimeter's functioning in areas of rough topography. A paper by Montgomery and Schmitt (submitted) documents the integration and functioning of the altimeter with the HRP.

Results

The Romanche Fracture Zone east of the main sill is an area of intense bottom intensified turbulent mixing. Figure 7 shows the mixing of AABW as it flows from west to east (left to right) across the sill. Temperature contours show the increase of bottom temperature from 1.1°C west of the sill to greater than 1.5°C to the east. The solid lines correspond to temperatures $\leq$1.9°C (AABW) and dashed lines represent warmer water. Along channel velocity is also shown at representative stations in the fracture zone and provide additional evidence of enhanced deep flow and mixing. Note the increased velocity near the bottom, especially at profiles 14 and 22.

Dissipation rates in excess of 10^{-6} W/kg within 200 meters of the bottom at some stations in the RFZ were observed. Averaged over the bottom 500 m, these data suggest a bulk mixing coefficient

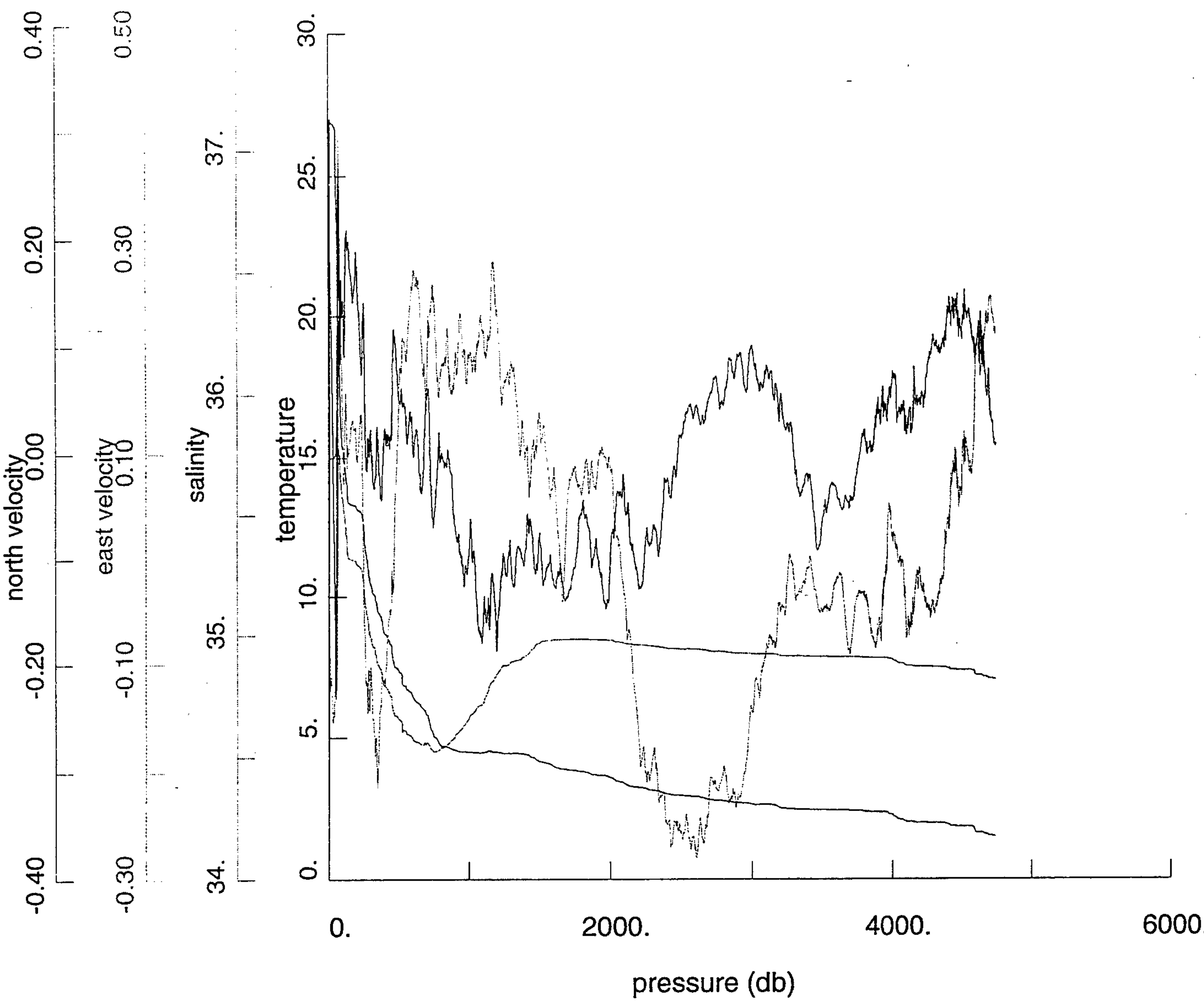

Figure 5: Profile of corrected temperature, salinity and velocity plotted against pressure.

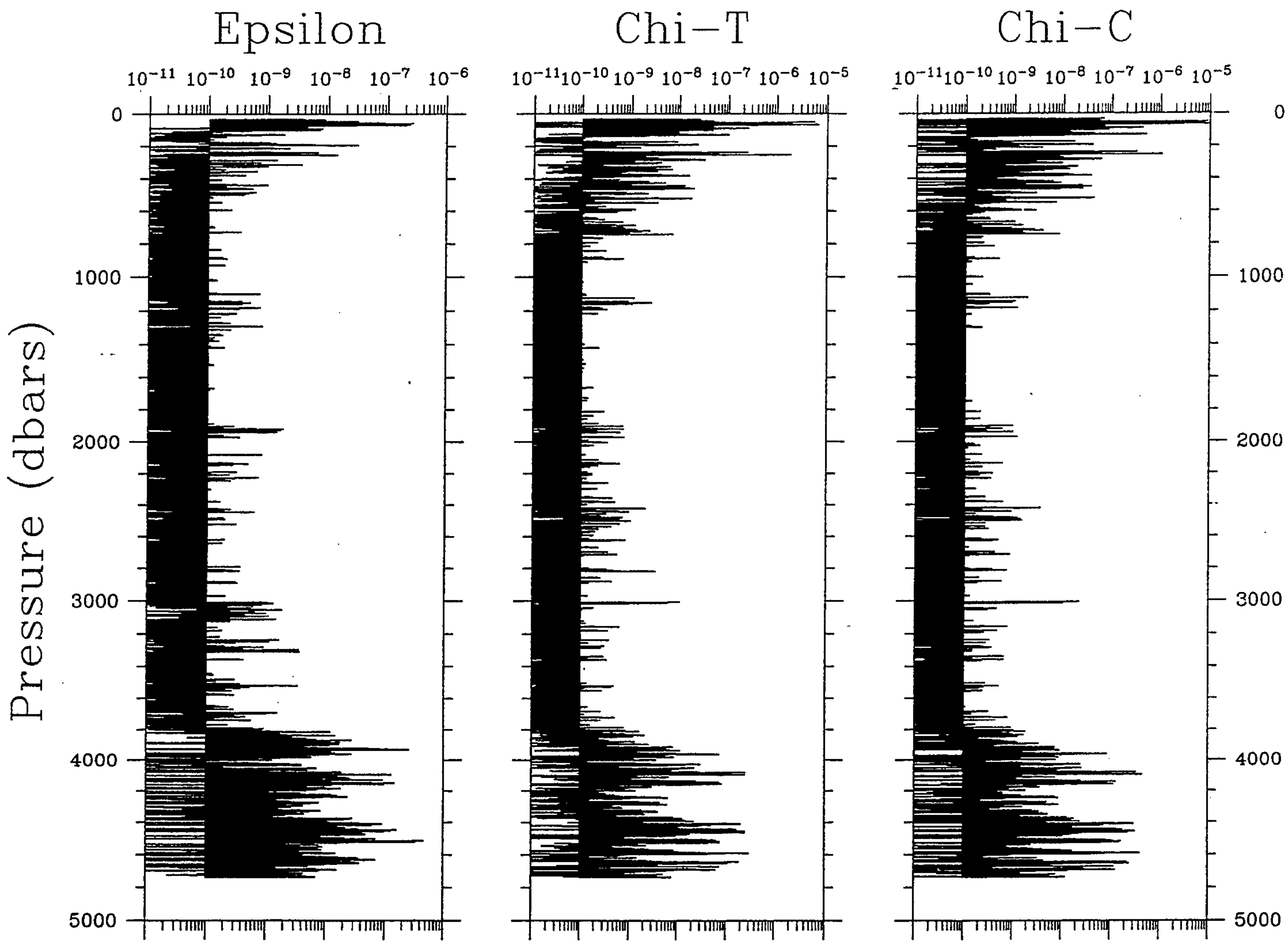

Figure 6: Final plots generated from microstructure data showing the three dissipation rates.

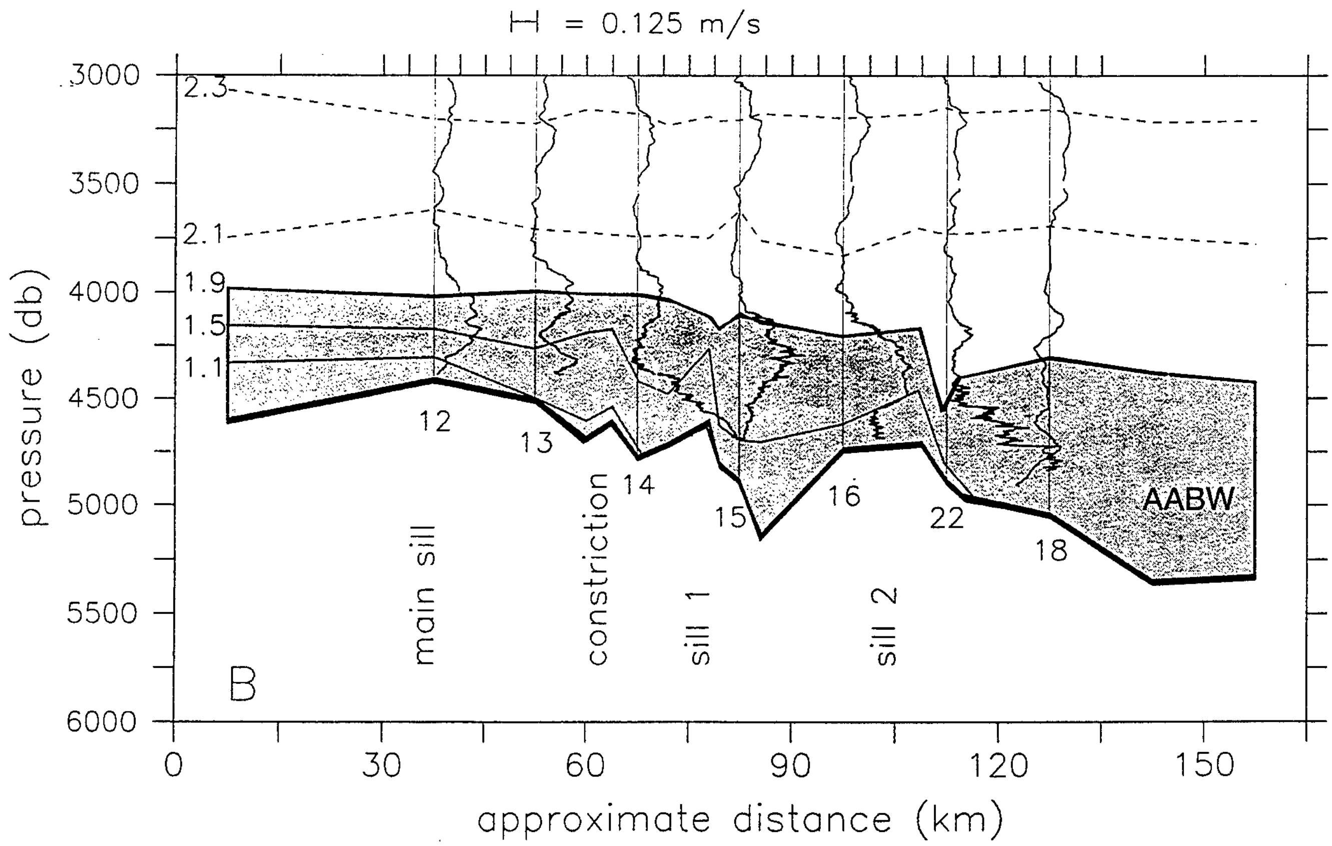

Figure 7: Crossectional view of the RFZ showing enhanced eastward velocities in the very deep areas and the temperature increase from west to east along the channel.

over the 30 km downstream of the main sill in excess of 100×10^{-4} m^2/s, which is 3 orders of magnitude larger than typical deep ocean values. Also, the velocity profiles obtained suggest that the transport through the RFZ is 1 Sv. The details of the mixing processes observed in this experiment are given by in Polzin *et al.* 1996.

Also during this experiment, the dynamics in areas of very rough topography associated with the Mid-Atlantic Ridge but away from the RFZ were compared to those in regions with relatively constant bottom slope. The profiles over rough topography reveal enhanced deep turbulent mixing, with diffusivity for the bottom 500 meters estimated to be greater than 10×10^{-4} m^2/s. Little, if any, enhancement is apparent at the bottom in regions where the bottom slope is constant and small.

On the transects across the equator, very robust deep jets with peak to peak velocities of 10–20 cm/s were observed. Our preliminary analysis indicates that we were able to resolve the meridional maximum in zonal velocity, and that the jets were displaced south of the equator by 1/2°.

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16. Abstract (Limit: 200 words)

Between November 20 and December 10, 1994, studies of the deep mixing processes in the Romanche Fracture Zone (RFZ) of the Mid-Atlantic Ridge were conducted from the French research vessel *N/O le Noroit*. Oceanographers from France and the U.S. worked together to acquire the unique data obtained on this expedition.

The cruise departed from and returned to Dakar, Senegal. Prior to the work in the RFZ, a sediment trap was recovered and returned to port. Two HRP engineering test dives were completed on the way to the fracture zone. The next week and a half was spent profiling with the HRP and CTD along the channel of the RFZ to identify regions of especially intense mixing. After that, two trans-equatorial sections were done with the HRP to examine the structure and intensity of the equatorial jets.

The presence of bottom intensified flow to the east along the RFZ and enhanced mixing of Antarctic Bottom Water were both observed. Based on the measurements obtained during this experiment, transport through the RFZ is estimated to be 1 Sv.

The work at sea, instrumentation, data return and some preliminary results are presented in this report.

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Antarctic bottom water

free vehicle

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